5.0 Safety

5.1 Introduction

The transportation, handling, storage, and processing of liquefied natural gas (LNG) and transportation of associated natural gas requires strict controls to minimize potential risks and interruptions of gas supplies. This section provides an overview of issues that would affect the safe and reliable operation of the proposed Port Ambrose Deepwater Port (Port Ambrose Project, Port or Project). This section is limited to design, engineering, and operational components of the proposed Project's infrastructure that, directly or indirectly, would have the potential to affect public safety. Reliability of overseas LNG supplies and shipping is outside the scope of this draft Environmental Impact Statement (EIS). Safety of personnel working onboard the proposed Project facilities, including process safety and vessel operations, is addressed in International Maritime Organization (IMO) Conventions and U.S. Regulation and would be fully addressed in the U.S. Coast Guard (USCG)-approved Deepwater Port Operations Manual prior to commencement of operations, and is also beyond the scope of this draft EIS.

5.2 LNG Hazards

5.2.1 Physical Properties

LNG is approximately 95 percent methane (natural gas) in liquid form. When the gas is cooled to -260°F (-162°C), it decreases in volume and becomes a clear and odorless liquid. LNG is transported and stored at near atmospheric pressure. As the liquid vaporizes and expands to form a gas, a pressure slightly above atmospheric pressure is maintained. This elevated pressure precludes air from entering the storage container.

LNG has several physical properties that are of interest:

- LNG is not toxic, but can act as an asphyxiant by displacing air;
- When initially released, cold LNG vapor remains heavier than air until it warms up and becomes buoyant;
- Natural gas at normal temperature (60°F [15.6°C]) and pressure (one atmosphere) is lighter than air;
- Natural gas at ambient temperature occupies 625 times more volume than LNG (methane liquid);
- When mixed with air, natural gas is flammable within the range of 5 to 15 percent. Outside this range, the gas is either too lean or too rich to support combustion;
- Compared to some other hydrocarbon fuels, natural gas has among the highest auto-ignition temperatures (e.g., higher than liquefied petroleum gas, gasoline, and diesel); and
- When spilled on water, a rare event known as rapid phase transition (RPT) can occur as the LNG very rapidly (near instantaneous) vaporizes from its liquid phase to its gaseous phase, resulting in a localized overpressure.

Methane, the primary component of natural gas, is colorless, odorless, and tasteless. It is not toxic, but is classified as a simple asphyxiant, possessing a slight inhalation hazard. If breathed in high concentration, oxygen deficiency can result in serious injury or death.

Methane has an auto-ignition temperature of 1,000°F (538°C) and is flammable at concentrations between 5 and 15 percent in air. Experience and testing indicate that unconfined natural gas vapor clouds do not explode. As the degree of confinement and congestion in the area surrounding a leak increases, the potential to explode rather than to flash also increases (Lees 1996). A vapor cloud, within the flammable range, located in a confined space can explode. In all cases, LNG vapors must be within the flammable range and an ignition source must be available (Juckett 2002). In the absence of an ignition source, a potentially flammable plume would migrate from the LNG leak source until the leak is isolated or until the LNG supply is exhausted and the air dilutes the concentration of natural gas to below the lower flammability limit (LFL). Due to the physical properties of natural gas, the gas cloud would quickly become buoyant.

Regardless of the cause, the formation of a methane/air mixture and its movement depends on the quantity and rate of the spill, whether it is on land or water, the atmospheric stability, the wind direction and velocity, and the temperature of the atmosphere and water.

There are five major hazard conditions associated with LNG that could have significant impacts over wide areas:

- Thermal radiation (flux) hazards;
- LNG pool fires;
- Flammable vapor clouds;
- Cryogenic hazards; and
- RPT.

5.2.2 Thermal Radiation (Flux) Hazards

Thermal radiation (flux) hazards can result from ignition of an LNG pool or ignition of a flammable LNG vapor cloud. Thermal radiation is the heat felt from the source. Hazards to humans include burns ranging from first degree to third degree, and can result in moderate to severe injury or death. The degree of a thermal radiation hazard is dependent on a number of factors, including distance from the thermal radiation source, exposure time, and shielding via personal protective equipment or structures. For human skin exposure to thermal radiation, a thermal flux of 1,600 British thermal units per hour per square foot (Btu/hr/ft^2) (5 kilowatts per square meter [kW/m^2]) would result in unbearable pain after an exposure of 13 seconds and second degree burns after an exposure of 40 seconds. Other thermal (fire) related hazards to humans include smoke inhalation and asphyxiation due to lack of oxygen.

In addition to human injury and fatalities, hazards to vessels and equipment are also possible due to thermal radiation. Literature reviewed indicates thermal flux levels of 11,900 Btu/hr/ft^2 (37.5 kW/m^2) can cause damage to steel tanks and process equipment. Thermal radiation hazards could be the result of either LNG pool fires or ignition of an LNG vapor cloud, which are further discussed below. Section 5.4 provides additional details regarding thermal radiation hazards and impact distances associated with pool fire and vapor dispersion at the proposed Port Ambrose facilities.

5.2.3 Pool Fires

Any rapid release of LNG from the LNG regasification vessel (LNGRV) onto water could result in a pool fire. In the event of a release, the LNG would float on top of the water and a pool would form. Heat from the seawater would warm the LNG pool and release vapors of natural gas to the atmosphere. A pool fire could occur in cases where methane, rising from the surface of the pool, combines with the proper mixture of oxygen (Section 5.2.4) and comes in contact with an ignition source. A large pool fire scenario is likely to be the highest risk in terms of the size of the thermal radiation hazard zone. Predictions regarding LNG pool fires are based on mathematical modeling and limited small-scale experiments, as there is no recorded instance of a large release of LNG on water or a resulting pool fire.

5.2.4 Flammable Vapor Clouds

LNG is less dense than water. If spilled and exposed to the atmosphere, it would absorb heat from the seawater and ambient air, initially forming a cold, heavier than air cloud that would be visible due to condensed moisture within the air. Because of the material's density and the turbulence created by the rapid boiling, an LNG spill would spread and vaporize rapidly. The initial cold air and LNG gas mixture is not buoyant between -260°F and -162°F (-162°C and -107°C). In the natural gas cloud, the amount of gas mixing with air would not be uniform, and pockets of the flammable gas/air mixture might exist in regions of the cloud that are generally outside the flammability limits of methane. If this flammable plume encounters an ignition source, a fire would flash back to the source of the spill, causing potentially serious burns to individuals within the flammable concentration zone. Sustained development and dispersion of a flammable vapor cloud is less likely to occur due to high probability that an ignition source would be present at the LNG spill resulting in a pool fire.

Thermal radiation is the primary mechanism of heat transfer from the burning methane to an individual or structure. When LNG initially vaporizes from its liquid state to its gaseous state, the methane concentration is high, resulting in insufficient oxygen levels to support combustion. When the concentration of methane decreases to approximately 15 percent of the vapor/air mixture (15 percent methane, 85 percent air), it would burn. This is known as the upper flammability limit (UFL). As the vapor continues to mix with more of the surrounding air, its concentration continues to decrease.

When the mixture is diluted to concentrations below approximately 5 percent methane (5 percent methane, 95 percent air), it becomes too lean to burn; this is known as the LFL. When an unconfined cloud containing a natural gas/air mixture burns in the open, the flame generally spreads from the ignition source back over the surface of the LNG vapor cloud.

The flame's rate of speed is only a few miles per hour. This flame speed is too slow to generate an explosion. Instead, the flame burns back to the source, and the primary concern is the radiant heat generated from the fire and the flames themselves. For LNG to cause an explosion, the vapor cloud must be confined. Large-scale field tests determined that releases of methane into the open air or onto water would not explode if ignited. Any methane that does not burn after being diluted below its LFL would dissipate into the atmosphere.

5.2.5 Cryogenic Hazards

As a cryogenic liquid, LNG quickly cools the materials it comes into contact with and causes extreme thermal stress in materials not specifically designed for ultra-cold conditions. These thermal stresses can cause brittleness or loss of tensile strength, and possible fracture of common materials of construction. Regarding worker safety, potential hazards include exposure to low temperature LNG and asphyxiation by concentrated vapors. The low temperature is sufficient to rapidly cause the equivalent of frostbite or, if enough of the body surface is exposed, death via freezing of the tissue.

The time frame for these potential impacts is limited. Even though the LNG vapor cloud is not toxic, the cloud might displace enough air to make the atmosphere unsafe for humans to breathe. This represents a hazard to the personnel in close proximity to the release, especially if there is some confinement that traps the vapor and allows the concentration to build up in the area.

5.2.6 Rapid Phase Transition

RPT occurs when LNG comes in direct contact with warmer water. In some cases, the rapid uncontrolled expansion of LNG as it changes from a liquid to a gas could result in a localized explosion caused by the physical energy released during the rapid expansion of the liquid to gas (Lees 1996). The hazard zones extending from an RPT are highly localized within or in the immediate vicinity of the spill area. RPT accidents, since considered to be negligible and highly localized, are probably of lower concern as compared to these other LNG-related hazards (Havens 2003). Since 1981, there have been several projects sponsored by the Society of Petroleum Engineers to investigate and develop a methodology for producing quantified estimates of the risk associated with the RPTs. Progress from this work is reported periodically in the *Journal of Petroleum Technology*.

5.3 Evaluation of Public Safety

For the purposes of this section, the public is defined as non-Project-related people. Liberty Natural Gas, LLC (hereinafter referred to as Liberty or the Applicant) is required to address the safety of Project personnel by complying with the regulations applicable under the Deepwater Port Act of 1974 (DWPA) and other applicable laws and regulations. The DWPA regulations require Port Ambrose personnel to be educated on the hazards involved in Port Ambrose's operation, trained in proper emergency and evacuation procedures, outfitted with appropriate personal protective equipment, and comply with other contingency plans and safety measures.[1] Many of the detailed contingency plans and safety protocols have not been developed at this phase of the DWPA licensing process. Such details are required to be included in the Applicant's Deepwater Port Operations Manual, which must be approved by the USCG prior to commencement of deepwater port operations. Therefore, this section considers hazard scenarios based on their potential to impact the public. Per the DWPA regulations 33 CFR 148.105(y), a project-specific Independent Risk Assessment (IRA) was prepared. The summary of the report can be found in Section 5.4 and the report is included as Appendix N of this draft EIS.

5.3.1 Safety Review Criteria

The safety review criteria used to complete the IRA were provided by the USCG with guidance from Sandia National Laboratories (Sandia). AcuTech Consulting Group, a third-party contractor selected by the USCG, with the input from local stakeholders, identified credible accidental and intentional scenario hazards, identified the bounding cases (worst credible impact), incorporated site-specific conditions, and reviewed direct impacts. The IRA reported resulting pool fire thermal radiation and vapor dispersion (to LFL) hazard distances for an unignited vapor cloud based on modeling performed for bounding accidental and intentional release scenarios. The process and considerations involved in modeling and developing the IRA are summarized below.

5.3.1.1 Credible Range of Release Scenarios

The evaluation of public safety must include an objective analysis of the impact of the proposed Port Ambrose Project on public safety and property. A hazard identification (HAZID) workshop was held on January 17 and 18, 2014, and the following agencies participated in the workshop:

- USCG Headquarters (Deepwater Port Standards Division and Navigation Division);
- USCG Sector New York;
- USCG District One;
- Maritime Administration;
- U. S. Bureau of Ocean Energy Management;
- New York State Department of Environmental Conservation;
- New York State Division of Homeland Security and Emergency Services;
- New York State Power Authority;
- New York State Department of State;
- New Jersey Department of Emergency Response;
- New York City Office of Emergency Management;
- New York City Fire Department;
- New York City Police Department;
- The Port Authority of New York and New Jersey;
- Board of Commissioners of Pilots of the State of New York;
- Sandy Hook Pilots;
- Maritime Association of the Port of New York/New Jersey Tug and Barge Committee; and
- Sandia National Laboratories.

[1] 33 CFR 148-150

A wide range of potential scenarios involving both accidental and intentional release hazards were considered in the workshop. From the identified hazards, six release cases (one accidental and five intentional) were identified and chosen to bracket the worst credible range of potential release scenarios on which to base the public safety evaluation. Further details regarding the identified hazards on which the IRA was based are provided in Section 5.4.

5.3.1.2 Site-Specific Input Data

Site-specific input data used in completing the risk assessment involved a description of the proposed Project: design information; proposed alternate locations; size of the LNGRVs; operating conditions for the offloading, storage, and regasification processes; meteorological data; and marine traffic data for the proposed Project's Region of Influence (ROI). Additional vessel traffic data from a number of sources, including the USCG Research and Development Center, were reviewed as part of the IRA for vessels transiting the vicinity of the proposed Port facilities. Site-specific intelligence information was also used in the determination of intentional scenario analysis.

5.3.1.3 Direct Impact on the Public

The purpose of the public safety evaluation and IRA is to review the proposed Project's potential safety and security impacts on the public and property in the subject area of the proposed Port facilities. The IRA considered potential direct impacts on humans and property from a potential worst-case(s) release of LNG from the proposed Port facilities. Indirect impacts on the public and property (e.g., economic impacts resulting from an LNG release) are not considered in the public safety evaluation. Also, project-related property and safety evaluation are not included in this study.

5.3.1.4 Bounding Case (Worst Credible Impact)

The public safety evaluation and the IRA process represent an assessment of the worst credible release scenarios representing maximum expected impacts from accidental and intentional events. What resulted from the evaluation were a representative set of scenarios and identification of the most significant potential and credible impacts (bounding cases) that could be used to access the public risks associated with construction and operation of the proposed Project.

5.3.2 Sandia National Laboratory Guidelines

In 2004, the U.S. Department of Energy (DOE) commissioned Sandia to develop a risk-based analysis approach to assess and quantify potential hazards and consequences of an LNG spill from an LNGRV. Sandia utilized previously completed studies and conducted its own studies to determine the hazards of an LNG spill. Sandia also developed risk management strategies to minimize the likelihood of an incident. The 2004 Sandia report – *Guidance on Risk Analysis and Safety Implications of a Large Liquefied Natural Gas (LNG) Spill Over Water* (Sandia 2004) is typically used as the industry standard and benchmark on which to base project-specific risk assessment studies.

The IRA followed the baseline guidance for accidental and intentional breach models of LNGRV inner hulls provided in SAND2004-6258 (Sandia 2004). AcuTech worked directly with the USCG and Sandia to apply site-specific conditions and parameters for the Port Ambrose Project IRA process. For the accidental worst credible scenario, Sandia collision data were extrapolated to account for larger oceangoing vessels with higher potential vessel energy that could occur in the vicinity of the proposed Port facilities. With respect to potential intentional threats, Sandia guidance suggested that the threat, breach, spill, and hazard analysis should be conducted on a site-specific basis.

Because of the increasing size and capacity of many new LNGRVs, at the request of the DOE, Sandia conducted detailed breach analysis, *Breach and Safety Analysis of Spills Over Water from Large Liquefied Natural Gas Carriers* (2008), for large LNGRVs ranging up to 9,358,387 cubic feet (ft^3) (265,000 cubic meters [m^3]). Based on the analysis, the range of breach sizes calculated for credible intentional scenarios appropriate for nearshore operations, where there is waterway surveillance, monitoring and control, ranged between 22 to 129 square feet (ft^2) (2 to 12 square meters [m^2]). For offshore operations, where there is less control and surveillance of ship operations, credible intentional scenarios can be larger and the calculated breach sizes can range from 54 to 172 ft^2 (5 to 16 m^2), with the most likely or nominal intentional breaching scenario resulting in an LNG cargo tank breach of approximately 129 ft^2 (12 m^2) (Sandia 2008). In their 2008 report, Sandia concluded that, in general, the worst-case scenario to public safety and property for the LNGRVs would be approximately within 2,297 feet (700 meters) of a spill, with minor damages as far reaching as 6,562 feet (2,000 meters); but recommends a project-specific risk assessment to determine hazard distances. Therefore, Sandia concluded that there is minimal risk to public safety and property from a larger LNGRV given the location of the proposed Port.

5.3.2.1 Risk Management for LNG Spills

Sandia describes separate "zones" of risk to consider when evaluating risk reduction strategies for accidental and intentional spills of LNG (see Figure 5.4-1).

- **Zone 1**. From ship to 11,900 Btu/hr/ft^2 (37.5 kW/m^2): In this area, the risk and consequences of a large LNG spill could be significant and result in severe negative impacts. Severe structural damage, including steel structures and immediate fatalities.
- **Zone 2**. Within Zone 2, 37.5 kW/m^2 to 5kW/m^2: The consequences of a large LNG spill are of varying damage. Options for structure and personnel protection required or negatively impacted.
- **Zone 3**. Less than 5 kW/m^2: Area where only minor impact on personnel would occur provided they move away from the fire (beyond 2,460 feet [750 meters] from major infrastructure, population/commercial centers or in large bays or open waters).

Because the proposed Project's location is at least 16.1 nautical miles (29.8 kilometers) offshore of any population or commercial centers, the proposed Project would have the lowest potential risk to public safety and property.

5.3.2.2 Risk Reduction Measures

Sandia concluded that the risks from a potential LNG spill over water could be reduced through a combination of approaches, including:

- Reducing the potential for a spill;
- Reducing the consequences of a spill; or
- Improving LNG transportation safety equipment, security, or operations to prevent or mitigate a spill.

The report identified several proactive risk management measures that should be evaluated when developing approaches to reduce both the potential for and resulting hazards of accidental and intentional LNG spills, including:

- Improvements in ship and terminal safety/security systems;
- Modifications and improvements in LNG tanker escorts, vessel movement control zones, and safety operations near ports and terminals;
- Improved surveillance and searches;
- Redundant or offshore mooring and offloading systems; and
- Improved emergency response coordination and communications.

While these risk prevention and mitigation techniques can be important tools in reducing both the potential for and the resulting hazards of a spill, especially in zones where the potential impact on public safety and property can be high, appropriate tools for each location might be different for effective risk reduction.

5.3.3 Impacts to Public Safety and Property

The proposed Project would be located 16.1 nautical miles (29.8 kilometers) offshore of Jones Beach, New York, and 27.1 nautical miles (50.2 kilometers) from the entrance to New York Harbor, minimizing the potential risk to the general public (see Figure 1-1). Based on the release modeling and the Port's location, even large flammable vapor clouds would not reach the shore and impact population areas.

In 2008, Sandia was commissioned by the DOE to conduct a series of large-scale LNG fire and cryogenic damage tests, as well as detailed, high performance computer models and simulations of LNG vessel damage resulting from large LNG spills and fires on water. The 2012 Report to Congress, *Liquefied Natural Gas Safety Research* (DOE 2012), summarized the key findings as follows:

- For the large breach and spill events considered, as much as 40 percent of the LNG spilled from the LNG vessel's cargo tank is likely to remain within an LNG vessel's structure, leading to extensive cryogenic fracturing and damage to the LNG vessel's structural steel. In addition to the cryogenic damage, the heat fluxes expected from an LNG pool fire would severely degrade the structural strength of the inner and outer hulls of an LNG vessel. The extent of the cryogenic and fire damage on an LNG vessel resulting from large spills and associated pool fires would significantly impact the LNG vessel's structural integrity, causing the vessel to be disabled, severely damaged, and at risk of sinking.
- Current LNG vessel and cargo tank design, materials, and construction practices are such that simultaneous, multi-cargo tank cascading damage spill scenarios are extremely unlikely, though sequential multi-cargo tank cascading damage spill scenarios may be possible. Should sequential cargo tank spills occur, they are not expected to increase the hazard distances resulting from an initial spill and pool fire; however, they could increase the duration of the fire hazards.
- Based on the data collected from the large-scale LNG pool fire tests conducted, thermal (fire) hazard distances to the public from large LNG pool fires will decrease by at least two to seven percent compared to results obtained from previous studies.
- Risk management strategies to reduce potential LNG vessel vulnerability and damage from breach events that can result in large spills and fires should be considered for implementation as a means to eliminate or reduce both short-term and long-term impacts on public safety, energy security and reliability, and harbor and waterways commerce. Approaches to be considered should include implementation of enhanced operational security measures, review of port operational contingency plans, review of emergency response coordination and procedures, and review of LNG vessel design, equipment and operational protocols for improved fire protection.

5.3.3.1 Deepwater Port

At present, only three LNG import facilities have been built offshore: the Gulf Gateway Energy Bridge Project, which commenced operations in March 2005 and ceased operations in June 2013; Northeast Gateway Energy Bridge Project, which commenced operations in May 2008; and Neptune Deepwater Port, which commenced operations in April 2010 and suspended operations in May 2013. A review of available information indicates there are no recorded incidents regarding impacts on public safety and property caused by deepwater port facilities. A review of available information is therefore limited to land-based LNG facilities and indicates there have been only seven documented incidents with one or more (worker and/or public) fatalities associated directly with operations at land-based LNG facilities: (1) Skikda, Algeria, January 2004; (2) Bontang, Indonesia, 1983; (3) Maryland, United States, 1979; (4) Arzew, Algeria, 1977; (5) New York, United States, 1973; (6) Raunheim, Germany, 1966; and (7) Ohio, United States, 1944. Two of the seven incidents were related to construction or maintenance activities at the LNG facilities and not directly to LNG operations (CH-IV International 2006). See Appendix O for details.

5.3.3.2 LNG Carriers

LNG carriers are designed, constructed and equipped to carry cryogenic LNG stored at a minimum temperature of -621°F (-163°C). The spherical and membrane types are accepted worldwide as cryogenic cargo containment systems. LNG carriers are constructed with spill and accident prevention measures incorporated into equipment design, operations, and safety training (ABS Consulting, Inc. 2004). The transportation of LNG by ship has proven to be an extremely safe method since the first LNG maritime shipment in 1959. Commercial maritime shipments of LNG began shortly thereafter in 1964. In 1980, the USCG determined that the level of risk associated with LNG maritime transportation is acceptable. There has not been any LNG-related loss of life to crews and no LNG-related injury to the public. The few minor incidents that have occurred are included in Appendix O.

More than 80,000 LNG carrier voyages have taken place, covering more than 100 million miles while loaded, with no major accidents, safety problems, recorded fatalities to vessel crew or the general public, or recorded fires on deck or within cargo areas. Out of the greater than 80,000 shipments of LNG since 1964, eight marine incidents worldwide have resulted in LNG spills. These spills have resulted in some damage to the LNG carrier, but no LNG fires have occurred (Sandia 2004). The most significant damage resulting from LNG leakage involved a deck or plating fracture from cryogenic embrittlement (CH-IV International 2006). An additional 11 incidents involved a vessel collision, a vessel running aground, or vessel fracture due to high seas deflection stresses. However, none of these 11 incidents resulted in the spillage of LNG (CH-IV International 2006).

As of November 2013, the world's LNG fleet was composed of 359 active LNG carriers, with another 28 LNG carriers on order worldwide (Auke Visser 2013). The majority of the LNG cargo capacities of these ships range from 0.7 million to 5.4 million ft^3 (19,821 to 152,911 m^3). Recently Q flex and Q max LNG carriers were put into operation. Q flex has a capacity of carrying 7.6 million ft^3 (215,208 m^3) of LNG. Q max has a capacity of 9.4 million ft^3 (266,178 m^3) of LNG capacity. Currently, all of these LNG carriers operate (or intend to operate) under a foreign (non-U.S.) flag with foreign crews and must have a Certificate of Compliance examination from the USCG when operating in U.S. waters to verify compliance with international safety standards and U.S. regulations. These ships are required to have an operations plan written in English and at least one officer aboard at all times who is fluent in English and is knowledgeable of the cargo systems (USCG and MARAD 2003).

5.3.3.3 Port Security

As part of the Deepwater Port Operations Manual, the Applicant would submit a Deepwater Port Security Plan (DWPSP) (33 CFR 150.15(x)). The purpose of the DWPSP is to provide the Applicant’s personnel who have security response responsibilities with a systematic approach to securing the deepwater port, and protecting personnel working at the proposed Project from human-caused threats such as theft, vandalism, or terrorism. The DWPSP would be included as an integrated component of the Deepwater Port Operations Manual.

After the events of September 11, 2001, the USCG reaffirmed its Maritime Homeland Security mission and its lead role, in coordination with other federal, state, and local agencies; owners and operators of vessels and marine facilities; and other entities with interests in the U.S. Marine Transportation System (MTS), to detect, deter, disrupt, and respond to attacks by terrorist organizations against U.S. territory, population, vessels, facilities, and critical maritime infrastructure. In December 2002, at the urging of the USCG, the United Nation’s IMO Maritime Safety Committee developed amendments to the 1974 International Convention for Safety of Life at Sea (SOLAS) intended to enhance maritime security.

The new International Ship and Port Facility Security (ISPS) Code was also adopted to provide a standardized, consistent framework for evaluating risk, enabling governments to offset changes in threat with changes in vulnerability for ship and port facilities. The implementation schedule of both the SOLAS amendments and the ISPS Code was July 1, 2004.

On a national front, the U.S. Congress enacted the Maritime Transportation Security Act (MTSA) in November 2002, which was designed to protect U.S. ports and waterways from a terrorist attack by requiring area maritime security committees and security plans for facilities and vessels that might be involved in a transportation security incident.

Accordingly, the USCG developed maritime security rules (33 CFR Subchapter H – Maritime Security) that require owners and operators of certain facilities in U.S. ports, and certain vessels operating in U.S. waters, to conduct a Facility/Vessel Security Assessment (FSA), name a Facility/Vessel Security Officer (FSO), and develop and implement a Facility/Vessel Security Plan (FSP). For Port Ambrose, the USCG, in conjunction with local stakeholders, prepared a site-specific IRA, which will form the basis of development of operational and security procedures in the Deepwater Port Operations Manual. If a License is issued, the USCG would require that Port Ambrose facilities and LNGRVs develop assessments and plans to ensure consistency with MTSA requirements.

In addition to the general risk preventions and minimization strategies discussed below, detailed prevention and mitigation strategies for both accidental and intentional release scenarios would be developed in a coordinated effort between USCG (CG-OES-4 and the Sector), local law enforcement officials, and the Applicant in the Deepwater Port Operations Manual and FSP, if the Maritime Administration (MARAD) License is approved. Process design and operational reviews and approvals also would increase safety by further preventing or minimizing potential risks. Although ongoing, much of this activity is completed in the post-licensing phase of the application.

Safety and security criteria for vessel and port operations were used in evaluating the proposed Port's location and would be critical components of the Port's design and operating procedures. For approval by USCG, the offshore location for Port Ambrose must be conducive to safety by minimizing any potential risks while simultaneously allowing for adequate security. The Port would be a minimum of 16.1 nautical miles from shore, and there are no existing offshore structures proximal to the proposed Port.

Federal regulations require all LNG vessels to provide a 96-hour advanced notice of arrival to the USCG prior to entering any U.S. port. Information about the vessel and its voyage, including its port of origin, cargo on board, crew members, passengers, status of essential equipment, and special security information, must be provided with the notice of arrival. All persons would be screened by the National Vessel Movement Center prior to the vessel's entry. Complete details concerning the USCG's notice of arrival requirements can be found in 33 CFR 160.

The USCG may routinely complete facility inspections, shipboard safety and security examinations, vessel escorts, and cargo monitors while a vessel is in U.S. waters or at a facility discharging its LNG cargo. A detailed Emergency Response Plan would be part of the Deepwater Port Operations Manual and DWPSP that would require the approval of the USCG during the post-licensing phase prior to beginning of operations, if the MARAD License were approved.

Under MSTA of 2002 and ISPS regulations, shipping companies, vessels, and facilities are required to have a security officer and a comprehensive security plan to conduct their operations. Port Ambrose would be required to develop a DWPSP, approved by the USCG in accordance with federal regulations. Similarly, LNGRVs would have a vessel security officer onboard to oversee security measures. A vessel security plan would be required as well. This plan would necessitate USCG review and approval prior to entry into the Port and would integrate with the overall DWPSP when the vessel is moored. Both the facility and the vessel would require specific and detailed contingency procedures to be developed within their security plans. Implementation of these procedures would be required to enhance safety and security; and to protect the vessels, their cargo, and the marine environment.

This plan would address security issues including, but not limited to, access control for people, goods and material; monitoring and alerting vessels that approach or enter the proposed Port Safety Zone and security zone (if administratively and non-regulatorily established by the DWPSP); identifying risks and measures to deter terrorist activity; internal and external notification requirements and response in the event of a perceived threat or attack on the proposed Project; designating a port security officer; providing identification means for personnel; security training requirements; actions and procedures that are scalable to the threat; emergency procedures such as evacuation; special operations procedures; and recordkeeping for periodic training, drills, and exercises. Additional requirements for the security plan include, but are not limited to, radar monitoring of the Safety Zone and any non-enforceable, self-monitored zones for situational awareness of vessel traffic in the general vicinity, that Port Ambrose may incorporate into the DWPSP, maritime security levels, ship security plans, ship security alarm systems, Automatic Identification System (AIS), and declarations of security between the proposed Port facilities and visiting vessels.

The USCG has a number of measures available to enforce security requirements and otherwise enhance security for vessels and port facilities in the United States. These measures include conducting random and targeted patrols and vessel boardings; reviewing information contained in vessel arrival notifications; conducting escorts and targeted boardings of vessels identified as high risk; conducting background intelligence checks; reviewing, approving and exercising vessel and facility security plans; and other appropriate actions designed to improve maritime security.

5.4 Deepwater Port Risk Assessment

In response to the Application filed with the USCG and the MARAD for the proposed Project, the potential risks to the public from the proposed Project, based on a large-scale release of LNG, were reviewed and an IRA was prepared (see Appendix N).

The USCG Office of Operating and Environmental Standards, Deepwater Ports Standards Division (CG-OES-4) directed the scope and content of the IRA. The Applicant did not influence the technical direction of the work performed for the IRA.

5.4.1 Purpose and Objectives

The purpose of the IRA was to develop a stand-alone technical report on the potential risks to the public from the proposed Project based on a large-scale release of LNG. The primary objective of the IRA was to assess impacts on the public and property not associated with the proposed Project from an event that compromised LNG containment.

5.4.2 Technical Approach

The IRA risk analysis involved the following six steps:

1. Deepwater Port area characterization – the Port Ambrose Project Application was reviewed, including specifics on the design of the location, expected size of the LNGRVs, operating conditions of the offloading, storage, and regasification operations, and information on the marine traffic in the area. Additional data, as required, were gathered and analyzed about the proposed Port environment.
2. HAZID process – input was received from various stakeholders to identify accidental and intentional scenarios that could potentially compromise the LNG tanks. AcuTech Consulting Group facilitated a team to identify events and provide a qualitative estimate of the potential consequences.

3. Scenario development – the list of accidental and intentional scenarios to be evaluated were established using information from the HAZID, as well as guidance provided in SAND2008-3153, and from Sandia to determine bounding scenarios.
4. Vessel frequency analysis – marine vessel traffic and overall statistical likelihood of the occurrence of a vessel collision with an LNGRV.
5. Consequence analysis – the impacts of the bounding cases (i.e., worst credible scenarios) were analyzed using computational fluid dynamics modeling for LNG spill rate, pool evaporation, thermal radiation and vapor dispersion.
6. Results and conclusions – the analysis results included a discussion of the potential impacts to the public from the proposed Project, and were based on the distances to the thermal radiation and flammable vapor dispersion endpoints for the scenarios modeled in the risk assessment.

The hazard zones are based on the breach size, release volumes, and weather conditions. The estimated size of the hazard zones would not be influenced by the size or configuration of the Safety Zone, No Anchoring Areas (NAAs) or the Area to be Avoided (ATBA) or whether the proposed Project is at the proposed location or at an alternative location. Thus, the size of each of the hazard zones depicted in the IRA would be identical, independent of the proposed and alternative locations as described in this draft EIS.

5.4.3 Deepwater Port Potential Impact

The conclusions of the IRA are presented as the hazard zones for thermal radiation and flammable vapor cloud dispersion for the accidental and intentional release scenarios evaluated. The hazard zones have been presented as graphical overlays on the nautical charts for the proposed Project location. The results of the study are presented without passing judgment on the merits of the Applicant's proposed Project.

While the study evaluated the potential impacts to the public and surrounding infrastructure, it did not attempt to predict the number of estimated fatalities or injuries from these events or any mitigation measures that could be implemented to reduce the risk of accidental or intentional release of LNG from this proposed Project. Mitigation measures to reduce the risk associated with an LNG release caused by both accidental and intentional scenarios will be proposed and evaluated in the Phase II risk assessment. For maritime security reasons, this information will not be made public; however, such measures identified may be included as conditions of approval for the deepwater port.

The proposed Project falls within the proposed area of interest for the wind energy project(s) proposed for offshore New York as described in the Bureau of Ocean Energy Management's (BOEM) Call for Information of May 28, 2014 (79 FR 30645). The risk assessment has taken this proposal into account; however, because of the lack of specific wind project details, the assessment is necessarily constrained in its ability to provide an analysis of the navigational safety risks that operation of the deepwater port may have on a future wind farm siting and operation. While it would be inappropriate to establish specific setbacks between the deepwater port, vessels operating in the area, and the wind farm, the IRA has provided information on LNG spill consequences, which would help inform any future offshore wind energy project proponent on future siting of wind turbines. Although there are no regulatory requirements, the USCG is currently working on guidance to address such safe wind turbine setback distances from shipping routes. In addition, should both the Applicant's proposed Project and any future offshore wind energy project move forward, risk management strategies would be developed to address the coexistence and simultaneous activities of both projects during construction and operation. These would include, but would not be limited to, simultaneous operations procedures, communications and coordination plans, emergency response plans, LNG carrier tug-assist, and specialized equipment and training as required. Requirements would be incorporated into the Deepwater Port Operations Manual, which must be approved by the USCG.

The scenarios investigated represent the bounding thermal radiation hazards for the intentional and vessel collision scenarios. A detailed discussion of potential risks to the public, as determined in the IRA (see Appendix N), from the proposed Project based on a large-scale release of LNG is provided in the following sections.

5.4.3.1 LNG Release Scenarios

A subset of accidental and intentional scenarios was analyzed in the IRA to identify the results of the potential worst-case credible scenarios. The HAZID identified 12 potential accidental release scenarios that have the potential to result in a release of LNG. These accidental scenarios included:

- Scenario 1 – Vessel Collision / Allision;
- Scenario 2 – Shipboard Mechanical System Failure;
- Scenario 3 – Fire;
- Scenario 4 – LNG Release at Process Equipment;
- Scenario 5 – Severe Weather;
- Scenario 6 – Structural Failure of LNG LNGRV (including the tanks);
- Scenario 7 – Grounding;
- Scenario 8 – Mooring System Failure;
- Scenario 9 – Aviation;
- Scenario 10 – Natural Phenomena;
- Scenario 11 – Dropped Objects; and
- Scenario 12 – Buoy Entanglement.

As part of the HAZID, a thorough review of potential intentional attack scenarios against an LNGRV and Port facilities were developed. These included scenarios required by the USCG to be considered for development of a security vulnerability assessment and facility security plan, such as standoff attack, ramming, hijacking, and other methods. Describing the weapons, tactics, and potential consequences in detail is not suitable for a public document; therefore, this combination of information is excluded.

The probability of intentional attacks cannot be accurately determined based on historical data. Therefore, potential events were not screened out based on any sort of frequency of occurrence. The selection of intentional scenarios for analysis was based solely on events that were deemed to be credible and that bound the potential consequences of an LNG release. For security reasons, intentional release scenarios and consequences have been defined in the report without presenting specific associated weapons and tactics. The intentional acts were evaluated in cooperation with Sandia who had input from local intelligence sources, and the most significant of the credible threats identified were analyzed.

Vessel collision had been discussed in the context of both accidental and intentional events. The more extreme result would be associated with an intentional event where no attempt is made to reduce the speed of the striking vessel. However, similar results would be produced by a vessel that is moving at standard speeds but inadvertently strikes an LNGRV calling on the proposed Port facilities.

The severity of a breach from an LNGRV following a collision with another vessel depends on the location of impact, vessel design, relative vessel speeds, collision alignment, and mitigation or prevention systems in-place to limit the potential damage. For the proposed Project, the membrane-type LNGRV design option was applied in the consequence analysis for the vessel collision scenario.

5.4.3.2 LNG Spill Consequence Analysis

The scope of the HAZID was the identification of "credible" scenarios for accidental and intentional events that would cause release of LNG. Credible scenarios as defined in the HAZID process represent scenarios with risks of all levels. They are possible intentional and accidental scenarios identified through a multidisciplinary team evaluation of the proposed Project. The scenarios are identified regardless of likelihood and are used in the Phase I IRA for bounding the consequences of concern.

Thermal radiation hazard distances from a pool fire were estimated to two different thermal heat flux levels:

- 11,900 Btu/hr/ft^2 (37.5 kW/m^2): Damage to process equipment and storage tanks for unprotected exposures based on an average 10-minute exposure duration, as well as immediate fatalities (Barry 2002).
- 1,584 Btu/hr/ft^2 (5 kW/m^2): Permissible level for emergency operations lasting several minutes with appropriate clothing based on an average 10-minute exposure duration (Barry 2002) and onset of second degree burns based on an average 40-second exposed duration (FEMA 1989).

The maximum thermal radiation hazard and flammable vapor dispersion distances predicted for the intentional and vessel collision scenarios are listed in Table 5.4-1. The IRA assumed that all spills originate at the LNGRV, with all hazard distances measured from the center of the LNG pool.

The flammable vapor dispersion hazard distance is determined as the maximum downwind distance to the LFL. The flammable vapor cloud dispersion simulations were performed using a Flame Acceleration Simulator (FLACS), a commercial Computational Fluid Dynamics (CFD) code. Given the right environmental conditions, the maximum distances could occur in the direction of prevailing wind at the time of release from the LNG release source.

All distances in Table 5.4-1 are measured from the center of the pool, which is the source of the LNG release. Note that the maximum pool diameters are different for the pool fire and vapor cloud dispersion cases. This is due to different boundary conditions (e.g., fire vs. no fire), as well as the different model applied to the analysis (e.g., equilibrium mass balance for pool fire vs. dynamic CFD model for vapor dispersion).

These scenarios represent the bounding thermal radiation hazards for the intentional and vessel collision scenarios. A pool fire at either buoy would not impact the other buoy location from a sustained fire at the 11,900 Btu/hr/ft^2 (37.5 kW/m^2) and 1,584 Btu/hr/ft^2 (5 kW/m^2) radiation levels. Additionally, the safety fairway is not impacted at these radiation levels. As compared to the pool fire consequence, where the thermal radiation hazard extends radially from the pool fire center, the flammable vapor dispersion hazard would extend as a cloud dispersing in the downwind direction of the prevailing wind.

The intentional scenario (Scenario 2) results in the greatest distance to LFL, and an intentional incident at either buoy could potentially impact the other buoy location (see Figure 5.4-1), assuming the wind direction was toward a second LNGRV at the adjacent buoy. However, given a dispersion duration of over 20 minutes to the other buoy location, the other LNGRV has an emergency buoy disconnect that can shutdown regasification and disconnect the LNGRV in 15 minutes.

In addition to impacting the other buoy, the dispersion distance to LFL from Scenario 2 (from Buoy #2) could also impact the Ambrose to Nantucket lane, depending on the wind direction at the time of release. As discussed above, a similar dispersion time of over 20 minutes is predicted for the cloud to reach the shipping lane.

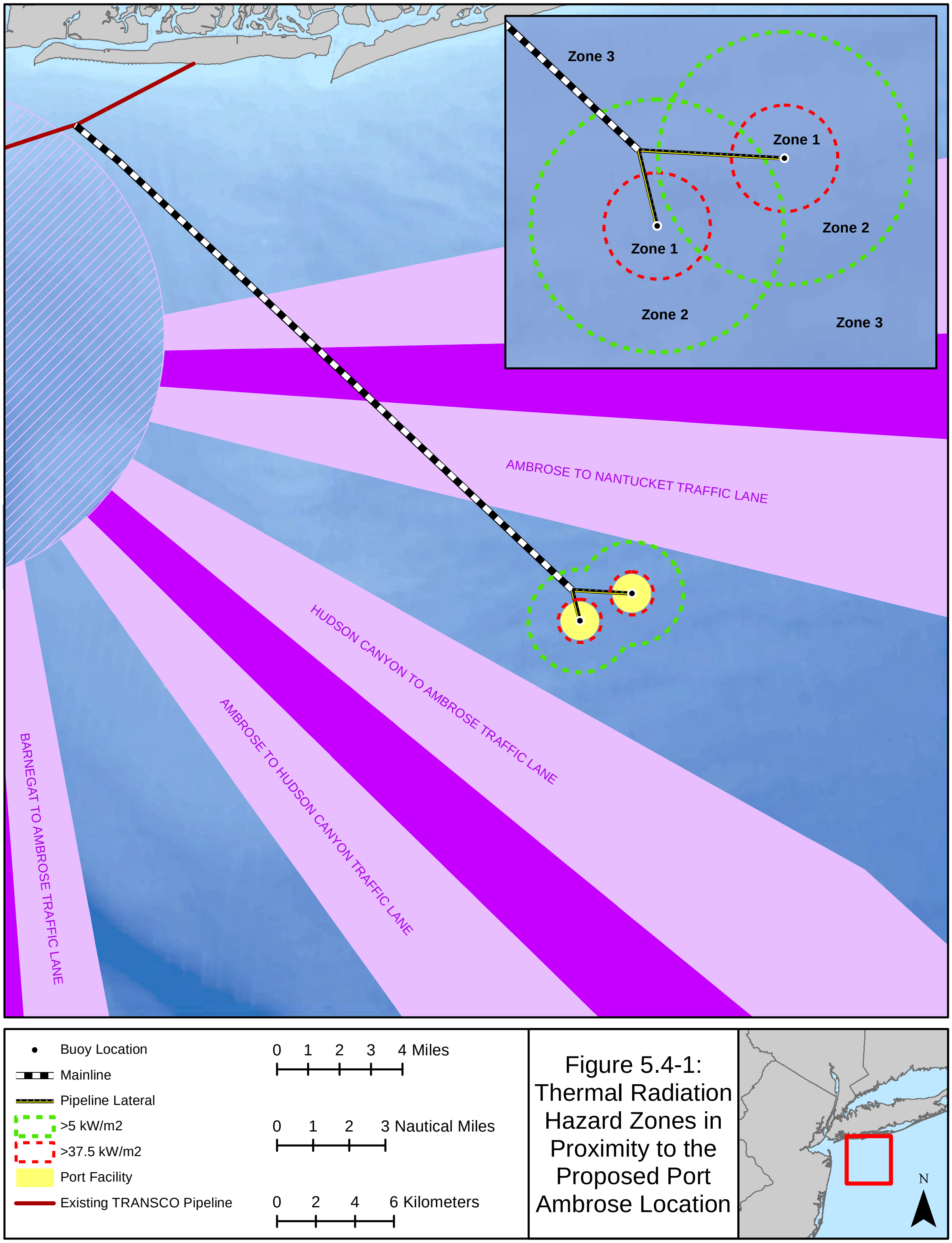

Figure 5.4-1. **Maximum Thermal Radiation Distances in Proximity to the Proposed Port Ambrose Location**

Worst Credible Scenarios

Following the HAZID process, the identified scenarios were further reviewed and a subset was selected for further development in the risk assessment. A report of all credible accidental and intentional scenarios identified in the workshop was submitted to the USCG, but is not appended here as it contains information pertaining to intentional acts, which has a homeland security concern. While the full HAZID is not presented, the key findings have been carried through this section and are included in the IRA (Appendix N).

A subset of accidental and intentional scenarios was analyzed in the IRA to identify the results of the potential worst-case credible scenarios. The process that the USCG requires for the evaluation of an LNG deepwater port project application is comprised of two phases: Phase I of the IRA evaluates the worst credible accidental and intentional scenarios; Phase II of the IRA will evaluate the full range of all possible releases to develop the safety and security strategy for the security and operations manuals. Phase II also discusses various mitigation measures that may be employed to reduce the risk of the identified hazards.

These scenarios lead to large-scale releases of LNG from either a 145,000 m^3 membrane-style LNGRV:

- Scenario 1: Intentional attack leading to a 16 m^2 breach in a single tank;
- Scenario 2: Intentional attack leading to a 12 m^2 breach in two tanks;
- Scenario 3: Hijacking attack leading to a 2 m^2 breach in a single tank;
- Scenario 4: Hijacking attack leading to a 5 m^2 breach in a single tank;
- Scenario 5: Hijacking attack leading to a 2 m^2 breach in two tanks; and
- Scenario 6: Vessel collision/allision leading to a 23.1 m^2 breach in a single tank.

The total volume of LNG spilled as well as the flow rate of LNG through a tank breach in an LNGRV depends on the location of the hole. The LNG spill volume and flow rate are maximum for holes at the waterline – in fact, if the hole is below the waterline, the flow of LNG out of the tank is decreased by the backpressure caused by the water above the hole (water is heavier than LNG and therefore the hydrostatic pressure outside the hole is higher than inside the hole), as well as by the flow of water into the tank. Other phenomena, such as ice formation around the hole and increased LNG vaporization as the spill flows towards the water surface, are also likely to result in overall smaller LNG pools for an underwater release, and consequently, smaller hazards to the public. Therefore, the conservative approach in all scenarios considered in this study is to assume that the tank breach occurs at the waterline (see Figure 2.1-4).

Since the IRA defines and analyzes only the bounding intentional and vessel collision scenarios, the intentional scenario with the largest thermal radiation and flammable vapor dispersion results and the vessel collision scenario (Scenarios 2 and 6 from above) will be the focus of the Port Ambrose results as presented below:

- Scenario 2: (Intentional attack leading to a 12 m^2 breach in two LNGRV tanks) is the bounding intentional scenario for vapor cloud dispersion and thermal radiation at the proposed Project; and
- Scenario 6: (vessel collision/allision with the LNGRV leading to a 23.1 m^2 breach) is the bounding accidental scenario for vapor cloud dispersion and thermal radiation at the proposed Project.

While the consequences of Scenarios 3 through 5 were determined as part of the Phase I risk assessment, the hazard zones will be reviewed in detail as part of the Phase II risk assessment. Therefore, the overlays for these three scenarios are not provided as results in Phase I since the location is not fixed. The Phase II risk assessment will use the hazards zones, as compared to the threat (to the proposed Port) and the vulnerabilities (based on the security measures for the proposed Project), to determine the risk for these scenarios and the need for additional security countermeasures.

Thermal Radiation Zones from Pool Fires

An LNG spill scenario can result in a pool fire when an LNG pool is formed onto the water surface and the vapors emanating from the pool are ignited close to the pool. The pool fire is fueled by the LNG that evaporates from the pool, as a result of heat transfer from the water underneath and the radiation from the fire above. The size of the LNG pool, and therefore the size of the pool fire, change with time as the pool spreads and recedes (see previous section). Therefore, the thermal radiation heat flux to a stationary target is a function of time, increasing when the pool expands towards the target and decreasing when the pool recedes towards the vessel. A conservative estimate of the radiation heat flux to a stationary target can be obtained by assuming the pool to be at equilibrium relative to the average spill rate – that is, the pool size is assumed to be such that the vaporization rate (under burning conditions) is equal to the mass added to the pool by the LNG spill.

Due to the lighter density of LNG relative to water, LNG spilling onto water will form a pool floating on the surface. The LNG pool will spread onto the water surface due to gravity forces, while some of the LNG will evaporate due to heat transfer from the water. The balance between LNG supply (spill flow from the tank) and removal (evaporation from the pool), as well as the dynamic balance of forces (gravity, inertia and friction), determine the size of the pool as a function of time. The LNG pool evaporation flux depends on the temperature difference between water and LNG, which is assumed to remain constant over time due to convective motion within the water column, through a heat transfer coefficient, which depends on both the physical properties of the fluids as well as the local relative motion between the spreading pool and the underlying water. Therefore, the evaporation rate varies in both time and space in a complex manner, yielding different results from the simpler, mass balance based calculations performed for the thermal radiation hazard analysis.

The behavior of the LNG pool on the water surface (spreading and vaporization) is calculated within FLACS. Note that the FLACS pool model is not constrained to assuming a circular (or semi-circular) pool shape; the pool spreads alongside the vessel and then wraps around the bow. Therefore, the pool "diameters" represent the diameter of an equivalent circular pool with the same area as the irregularly shaped pool calculated by FLACS.

With the exception of the LNGRV, there are no other structures or geometric obstacles expected to be in proximity of the proposed Project that could affect the growth of a pool fire or shield potential targets from the fire's radiation. Therefore, CFD models of the pool fire are not deemed necessary and simpler models can be used to calculate the thermal radiation hazard distances.

Table 5.4-1 details the pool fire consequence results for the intentional (Scenario 1-2) and vessel collision (Scenario 6). This table details the number of tanks breached, release quantity (from the tank(s) breached), and distances to the 11,900 and 1,584 Btu/hr/ft^2 (37.5kW/m^2 and 5kW/m^2) thermal radiation endpoints.

Flammable Vapor Cloud Dispersion

The dispersion of LNG vapors from a spill on water was calculated using the FLACS CFD model and the parameters described earlier. A simple model of the LNGRV is included in the FLACS 3D model for these simulations. According to the proposed plans, the unloading vessels would be moored to the buoy and therefore would be able to weathervane while at berth. Therefore, in the simulations the vessel is assumed to be aligned with the wind direction. The tank breach is assumed to occur at the waterline, at midship on the port side of the LNGRV (see Appendix N).

The vapor cloud dispersion hazard distance was reported as the maximum downwind distance to the LFL. The flammable vapor cloud dispersion simulations were performed using FLACS (see Appendix N). The distances to LFL predicted by FLACS for the intentional and accidental release scenarios are detailed in Table 5.4-1. All distances are measured from the center of the LNG pool.

The major hazard of this consequence is the ignition and combustion of the flammable gas within the cloud, called a flash fire. A flash fire can result in potential impacts to the public and property. Due to the speed of the flame (as it propagates from the ignition source through the flammable range of the cloud), the impacts would be highly dependent on an individual's location (indoors vs. outdoors) and on the construction of the property exposed to the fire.

Thermal radiation effects from the vapor cloud fire can extend outside the flammable portion of the cloud and could result in a larger hazard distance as compared to the distance to LFL. But, due to the transient nature of this fire, the exposure duration from a flash fire is much shorter than exposure duration of a pool fire and is thus much shorter than the basis for the thermal radiation endpoints. Assuming the flame acceleration of the flash fire is not impacted significantly by obstacles (consistent with the open nature of the deepwater port locations), the expected flame speed through the cloud could range from 8 to 17 meters per second (Raj et al. 1979). At these flame speeds, the exposure duration would not be significant, thus requiring a much higher thermal radiation exposure to result in comparable impacts to those listed in Table 5.4-1. Due to the uncertainty in the thermal radiation effects outside the flammable range of the vapor cloud, no additional thermal radiation has been considered and the hazard distances reported are limited to the distance to LFL.

Table 5.4-1. Summary Risk Analysis Consequences for Bounding Scenarios

Result	Scenario 1 (Intentional)	Scenario 2 (Intentional)	Scenario 6 (Collision)
Breach Size, square meters [m^2]	16	12	23.1
Number of Tanks	1	2	1
Total Capacity of Impacted Tank(s), m^2	41,429	82,857	41,429
Release Quantity, cubic meters (m^3)	29,000	58,000	29,000
Pool Fire Maximum Distance to Endpoint (meters)			
Pool Diameter, meters	579	709	696
Thermal Radiation Endpoint >11,900 Btu/hr/ft^2 (37.5 kW/m^2)	970	1,110	1,090
Thermal Radiation Endpoint >1,584 Btu/hr/ft^2 (5 kW/m^2)	2,270	2,640	2,600
Flammable Vapor Cloud Dispersion (No Ignition)			
Maximum Pool Diameter, meters	533	556	541
Distance to LFL, meters	2,800	3,550	2,750

The actual hazard of the flammable vapor dispersion consequence is only in the downwind direction, and only within the LFL (5 percent methane concentration level) contour. The contour is the outer shape of the cloud out to a concentration equal to the LFL. As a result of the large release quantities and large pool sizes associated with the bounding cases of the IRA, the LFL contour does not result in a dispersion profile with a classical cigar/elliptical shape. Near the origin of the spill, the shape of the cloud is dominated by heavy gas effects and farther downwind, the cloud transitions to the more classical dispersion profile, tapering off at the maximum LFL distance. While the hazard zone is depicted as a circle to account for all wind directions, not all portions within the circular hazard zone are expected to be impacted from a release (Figure 5.4-2).

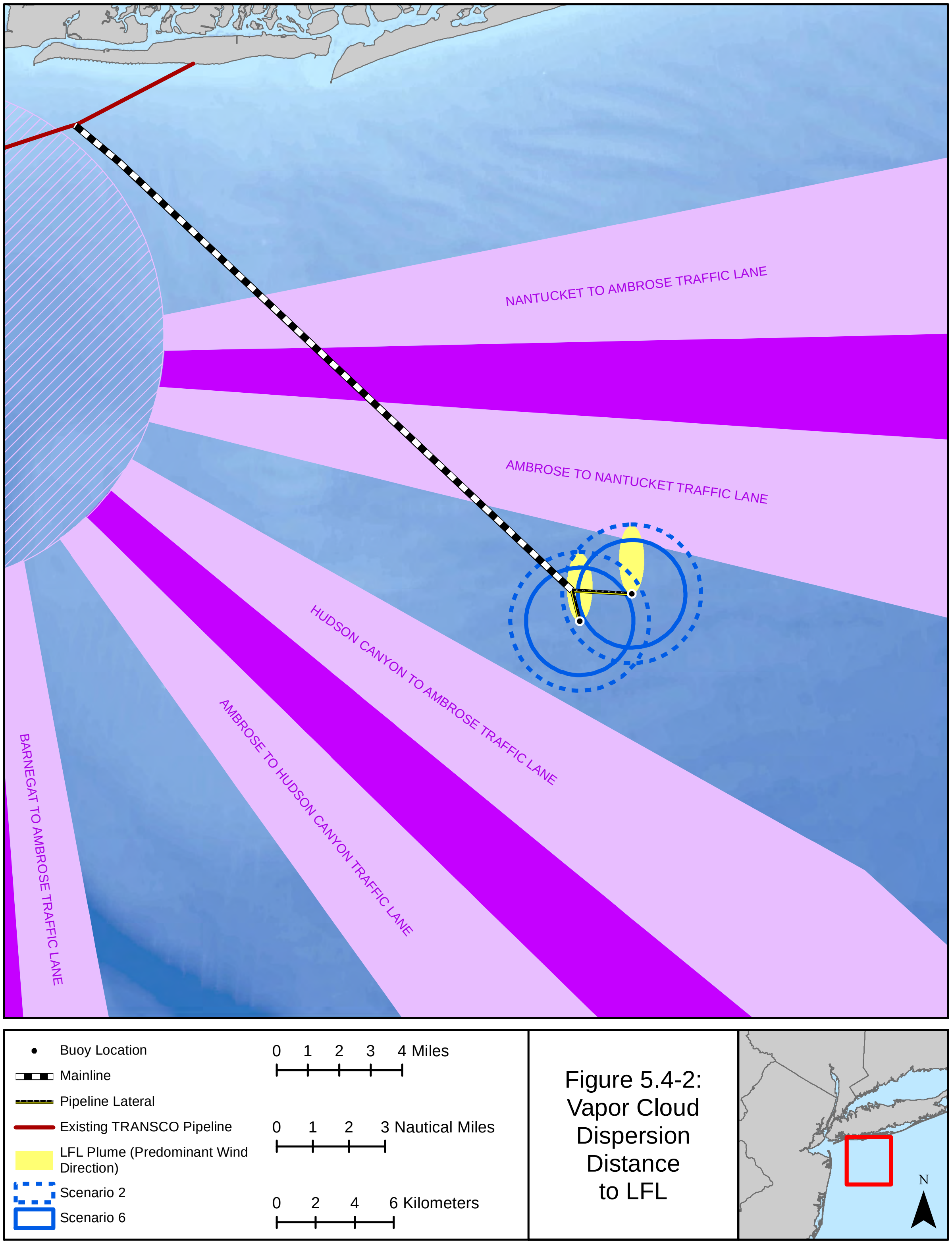

Figure 5.4-2. Vapor Cloud Dispersion Distance to LFL

5.4.3.3 Frequency of Collision

The total frequency of a collision with an LNGRV at the proposed Port facilities was calculated for two vessel types: (1) vessels in the established Ambrose to Nantucket lane and the Hudson Canyon to Ambrose lane; and (2) vessels randomly passing the location of the proposed Port facilities. This calculation utilized vessel traffic from the AIS dataset provided for this proposed Project by the USCG R&D Center, and only included those vessels with the potential to breach the inner hull of the LNGRV (resulting in a release of LNG from containment) in a collision.

Due to the distance between the proposed Project and the vessels in the two adjacent traffic lanes, the likelihood of a powered and drifting collision from vessels in these defined routes and the LNGRV was unlikely. In addition to vessels in the defined fairway, vessels of sufficient displacement and speed were identified that passed near the proposed Project. Using the collision frequency calculation for randomly distributed vessels, the likelihood for these vessels colliding with the proposed Project was calculated. However, given the small number of random vessels and the size of the LNGRV, the likelihood is also unlikely.

The collision frequency for the proposed Port facilities considering both vessels in the two adjacent traffic lanes and randomly distributed around the proposed Project is shown in Table 5.4-2.

Table 5.4-2. Frequency of Vessel Collisions for the Proposed Deepwater Port

Traffic Location	Annual Frequency of Collision (Collision per Year)	Collision Estimated Period (Years per Collision)
Ambrose to Nantucket Lane	2.13×10^{-5}	1 collision every 47,000 years
Hudson Canyon to Ambrose Lane	7.98×10^{-9}	1 collision every 125,000 years
Randomly Distributed	1.67×10^{-8}	1 collision every 60,000 years
Total	**2013×10^{-5}**	**1 collision every 47,000 years**

5.5 Marine Safety

Marine safety for vessels, deepwater ports, and offshore structures is regulated through a framework of overlapping international treaties and standards; national laws and regulations; and federal and state port- or area-specific rules. The agency with primary responsibility for vessels and deepwater ports in the proposed area is the USCG. The USCG currently boards foreign-flagged vessels under the Port State Control program, and may board, inspect, and search any vessel entering a U.S. port. The USCG is also charged with a lead role in all aspects of application and approval of deepwater ports; reviewing and approving operations and security plans; and periodic inspection of the facilities (once constructed) to enforce compliance with environmental, safety, and security requirements.

5.5.1 Marine Safety Standards

In accordance with 33 CFR 150, the licensee of the deepwater port could not operate the Port without prior USCG approval of the Deepwater Port Operations Manual. If the MARAD License is granted to the Port Operator, it would require that the Operations Manual address the requirements of the DWPA and provide detailed specifications and procedures for all aspects of Port operations and infrastructure. The Operations Manual would address security, emergency response, public and personal safety, protection of the environment, navigation, vessel movement, materials handling, and personnel qualifications. The Operations Manual would be required to address Port requirements for calling vessels, approaches, Safety Zone, port infrastructure, and pipelines.

If the proposed Project is approved and commences operations, the USCG would conduct regular inspections to ensure that the Operations Manual is being properly implemented. In addition, the USCG would review the Operations Manual from time to time, and propose or require amendments as necessary to meet the intentions of the appropriate regulations and address potential changes in conditions.

Marine safety would be enhanced, in part, by navigation aid systems, fire and gas detection systems, emergency shutdown systems, and communication systems.

In addition, during the construction phase of the proposed Port, the USCG would be responsible for approval and oversight of design, fabrication, installation and construction, and commissioning. Any substantive changes that would affect the Deepwater Port Operations Manual and equipment would also have to be reviewed and approved. The USCG would also coordinate with the Pipeline and Hazardous Materials Safety Administration (PHMSA) as the technical and approval authority of pipeline design, construction, operations and maintenance.

5.5.1.1 Navigation Aid Systems

The USCG has requirements for indicating the location of fixed structures on nautical charts, and the USCG 1st District's Local Notice to Mariners (LNMs; monthly editions and weekly supplements) informs local mariners about locations of aids to navigation. Additionally, Marine Safety Information Broadcasts (MSIBs) would be issued whenever Port-related activities (e.g., construction, marine mammal monitoring or general Port operations) are occurring.

The LNGRV would be equipped with all appropriate navigation lighting aid systems required for moored or berthed vessels. The proper day signals or navigation lights would be visible during the appropriate times of day and will comply with the 1972 International Rules of the Road (72 COLREGS) requirements. The 72 COLREGS govern the color, placement, range of visibility, and use of lights and shapes on all seagoing vessels and apply to all vessels operating on U.S. waters outside inland demarcation lines. At night, lighting would be appropriate for a vessel at anchor and conducting operations (deck lighting) for better visibility from passing vessels. An AIS would transmit the name and position of the LNGRV.

5.5.1.2 Fire and Gas Detection System

The Applicant would be required to comply with applicable codes and standards for the LNGRV safety systems and equipment onboard the vessel. These systems and equipment include detection, emergency shutdown, spill containment, fire protection, flooding control, crew escape and safety shelters, and all other such equipment as required by applicable federal and international regulations and standards.

The International Gas Code (IGC) requires that each cargo tank be outfitted with an integrated instrumentation/alarm system that notifies the crew of possible leaks via gas detection and temperature sensors and tank liquid levels, temperatures, and pressures. These systems, as well as the pressure relief systems mentioned above, provide a many-layered protection against cargo release either through equipment malfunction or human error. Additional gas detection systems (integrated instrumentation/alarm systems) are required by the IGC in spaces where cargo is located, including compressor spaces, spaces where fuel gas is located, and other spaces likely to contain gasified cargo. Venting systems for certain spaces and portable gas detectors are also required. Cargo loading areas and docks are also required by the IGC to be equipped with LNG vapor and fire detection systems that automatically shut down the transfer systems in the event of a leak or fire. Personnel on the loading dock or the LNGRV can also manually operate these shutdowns.

5.5.1.3 Emergency Shutdown System

Emergency shutdown (ESD) is controlled by automatic or manually activated systems:

- Automatic shutdown through the fire and gas detection or other systems on the LNGRV requiring a total shutdown of gas export; and
- Manual shutdown through ESD buttons positioned at strategic locations.

Automatic or manual operation activates closed all of the three ESD valves (ESDV) which are located:

- ESDV1 – ESD valve mounted on main deck upstream of the STL Buoy system;
- ESDV2 – ESD valve mounted in the STL Buoy; and
- ESDV3 – ESD valve mounted subsea in the PLEM.

The ESDVs are operated by spring return, hydraulically powered actuators with a fail-safe spring return to the closed position. The hydraulic power for operation of the valves is supplied from the STL valve control system. The signal for indicating the open or closed position of the valves would be sent to the vessel control system.

Emergency buoy disconnect (EBD) can only be activated manually through the EBD button located on the STL operator panel on the LNGRV navigation bridge. EBD involves a shutdown of the gas export operation followed by an automatic disconnection of the STL Buoy. The EBD is initiated through push-button activation in two steps. Step one disconnects the STL gas transfer system while step two releases the STL Buoy. Total time required for the vessel to complete an emergency STL buoy disconnect operation is estimated to be approximately 15 minutes.

5.5.1.4 Communications System

The Applicant has stated that all moorings and departures by LNGRVs to or from the proposed Port facilities would be carried out at the LNGRV Master's discretion, as set forth in the Applicant's Deepwater Port Operations Manual. The dedicated support vessel would be within the proposed ATBA during all LNGRV arrivals and departures. Prior to arrival or departure, the LNGRV Master would make a broadcast via VHF radio to warn any vessels in the area that the LNGRV would soon arrive or depart. As the LNGRV prepares to arrive or exit the proposed Port facilities, the LNGRV Master would evaluate weather conditions and determine the safest procedures and route for arriving or departing. The proposed Project facilities would not be made available to provide bunkers (fuel and diesel oil) or fresh water to moored LNGRVs.

5.5.2 Navigational Safety Measures

The navigational safety measures within the Safety Zone, NAAs, and the ATBA discussed below would be incorporated into Port operations with final dimensions and mandatory or recommendatory restrictions yet to be assessed for safety and security. It is likely, however, that the proposed dimensions would be a starting point for this assessment.

5.5.2.1 Safety Zone

The DWPA requires the establishment of a zone of appropriate size around and including any deepwater port for the purpose of navigational safety. In such zone, no installations, structures, or uses are permitted that would be incompatible with the operation of a deepwater port.

The USCG has promulgated regulations that provide requirements for the establishment of, restrictions, and location of safety zones, NAAs, and ATBAs around deepwater ports (33 CFR 150 Subpart J).

As set forth in the application, the proposed Safety Zone would have a radius of 1,640 feet (500 meters) from the center of each STL Buoy encompassing a combined area of approximately 388 acres or 0.6

square mile (Figure 2.1-12).[2] All unauthorized vessels would be prohibited from anchoring or transiting the proposed Safety Zone at any time.

5.5.2.2 No Anchoring Area and Area to be Avoided

In addition to the Safety Zone, NAAs and an ATBA are proposed to be established.[3] As set forth in the application, the proposed NAAs and the ATBA would be the same size with a radius of 3,281 feet (1,000 meters) measured from the center of each STL Buoy.[4] This would be approximately 1,552 acres or 2.4 square miles around each buoy (Figure 2.1-12).

Both the NAAs and the ATBA would appear on subsequent editions of local and regional nautical charts. No vessels would be allowed to anchor in the NAAs to prevent damage to the STL Buoy and mooring system or damage to the Port's equipment from entanglement. The restriction would likely also apply to bottom trawling. The ATBA is meant to discourage vessel traffic. It would help ensure that other vessels do not interfere with the deepwater port's operations, including the maneuvering of the LNG carrier and its support vessel. Both the NAAs and the ATBA are normally recommendatory.

LNGRV traffic would be coordinated by Liberty personnel (Figure 2.1-13).

5.5.2.3 Designated Anchorage Areas

The Applicant has indicated that they do not intend to use designated anchorage areas in the event that LNGRVs must delay their arrivals to the proposed Port facilities. Incoming LNGRVs would instead vary their speed and course in order to arrive at the proposed Port facilities when conditions are clear.

5.5.3 LNG Vessel Support

The Applicant has stated that all moorings and departures by LNGRVs to or from the proposed Port facilities would be carried out at the LNGRV Master's discretion, as set forth in the Applicant's Deepwater Port Operations Manual. The dedicated support vessel would be within the proposed ATBA during all LNGRV arrivals and departures. There will be no bunkering of LNGRVs at the proposed Port facilities; thus, no vessels would be needed for that purpose. Similarly, there would be no natural gas export operations; therefore, no liquefaction vessels would operate at the proposed Project.

LNGRVs would rely upon the dedicated support vessel for monitoring and control purposes, as well as periodic supply and personnel transfers. This vessel would be an ocean class towing vessel of up to 130 feet (40 meters) in length, a bollard pull (ahead/astern) of approximately 75 metric tons, and a draft of roughly 23 feet (7 meters), and would be powered by diesel engines with up to a total of 5,000 horsepower. It would be staffed by a crew of four to six. The support vessel would be equipped with firefighting capability up to DNV FiFi Class 1 requirements.[5] The support vessel would remain on station at the proposed Port for the duration of the LNGRV's visit, including arrival and departure.

The support vessel would conduct weekly inspections of surface components of the proposed Port facilities and would make approximately one trip per LNGRV arrival from a base of operation on the mainland.

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[2] As a matter of practice, if an LNG carrier is present and on the buoy, the USCG would extend the Safety Zone by a distance equivalent to the length of the LNG carrier (approximately 300 meters in length) to account for weathervaning (rotation) of the vessel around the STL Buoy, a distance of approximately 2,624 feet (800 meters).
[3] NAAs and ATBAs are established by the IMO pursuant to a request from the U.S. Government. If approved, each zones' specific boundary would be set forth via regulation.
[4] Past practice has been that ATBAs have a radius of at least 820 feet (250 meters) longer than that of the NAAs for appropriate stand-off, which would occupy an area of 1,213 acres around each buoy.
[5] Class notational FiFi 1 means the vessel is capable of providing initial response, in-close firefighting, via two fire monitors. The fire monitors must have a total capacity of not less than 10,560 gallons per minute (gpm) and be able to throw a water stream of a minimum of 394 feet.

5.5.3.1 Vessel Safety and Collision

The collision frequency for the proposed Port considered both vessels in the two adjacent traffic lanes and randomly distributed around the proposed Project. Due to the distance between the proposed Project and the vessels in the two adjacent traffic lanes, the likelihood of a powered and drifting collision from vessels in these defined routes and the LNGRV was unlikely. In addition to vessels in the defined fairway, vessels of sufficient displacement and speed were identified that passed near the proposed Project. Using the collision frequency calculation for randomly distributed vessels, the likelihood for these vessels colliding with the proposed Port was calculated. However, given the small number of random vessels and the size of the LNGRV, the likelihood is also unlikely (see Section 5.4.3.3 and Table 5.4-2).

5.5.3.2 Mooring and Berthing

The unloading buoy technology and associated equipment proposed for the Project is similar to that used offshore in projects for Massachusetts. The technology has also been successfully used in the offloading of oil and natural gas at several locations overseas, including the North Sea. Each unloading buoy would have eight mooring lines consisting of wire rope and chain. The mooring lines would connect each unloading buoy to eight anchor points consisting of piles on the seabed. The unloading buoy is designed by Advanced Production and Loading, and is also commonly known as a STL™ Buoy. See Section 2 for a detailed discussion of the proposed Port facilities.

5.5.3.3 Extreme Weather

The LNGRVs would monitor current and forecasted weather conditions through regular monitoring of the vessel's equipment (such as radar, barometer, anemometer, and visual observation from the bridge) as well as monitoring National Weather Service internet and VHF voice broadcasts of current and forecasted marine conditions, Dial-A-Buoy service from Station 44065-Entrance to NY Harbor, real-time weather radar satellite imagery via internet, and mass media weather broadcasts available by satellite on the vessel's TV system.

At the first sign of significant weather, the Port Manager and LNGRV Master would determine the Master's needs and plans for storm evasion, such that any order to evacuate would be done in a manner timely enough to allow safe weather evasion. Evacuation due to forecasted weather in excess of the limits below would be ordered by the Port Manager in consultation with the LNGRV Master, and in accordance with the Captain of the Port New York Hurricane and Severe Weather Plan. Proper notifications and consultations with the USCG would be made.

In addition, the STL Buoy system components are designed for:

- LNGRVs to stay connected in the 10-year storm condition; and
- Idle STL Buoy system would survive the 100-year storm condition.

The maximum sea state for connection for an LNGRV to a STL Buoy is:

- Significant wave height of 9.8 feet (3 meters);
- Wind speed of 30 knots (15 meters per second); and
- Current speed of 2.9 knots (1.5 meters per second).

Severe weather was considered in both the Port Ambrose Project application and during the HAZID process. Due to the relatively predictable weather around the proposed Port facilities, combined with the robust ship and equipment design, procedures to predict adverse weather conditions, and the ability to disconnect from the buoy should severe weather develop suddenly during transfer operations, significant damage to an LNGRV or the deepwater port due to severe weather is considered unlikely.

5.6 Offshore Pipeline Safety

The Mainline and pipeline laterals are subject to, and the Applicant must comply with, the pipeline safety laws and regulations administered by the U.S. Department of Transportation, Pipeline and Hazardous Materials Safety Administration (PHMSA), Office of Pipeline Safety (49 U.S.C. Chapters 601 and 603 and 49 CFR 190-199), including safety standards for design, construction, testing, operation, maintenance, and reporting. Pipe wall thickness, shutoff valve spacing, external pipe protective coating, cathodic protection, underground clearance, and depth of cover would comply with the pipeline safety regulations. Inspection of pipeline welds, materials and external protective pipe coating and hydrostatic testing would be performed prior to placing the pipelines in service. The Applicant would periodically inspect the pipelines to ensure protection from any changes in operating and maintenance conditions including inspection of pipeline after significant events, i.e., earthquakes or hurricanes.

The Mainline and pipeline laterals proposed by the Applicant would be designed to accommodate in-line inspection tools (smart pigs) for integrity inspections. Smart pigs have a variety of sensors (e.g., magnetic and ultrasound) to measure the wall thickness of the pipe around the circumference as it travels internally. The use of smart pigs would provide a reliable record of changes in pipeline conditions to ensure that pipeline integrity is maintained. The frequency of pipeline inspection by pigging and other surveillance measures to confirm integrity would meet or exceed the requirements of all applicable regulations and guidelines.

The Applicant would comply with all applicable regulations regarding operating and maintaining the proposed Mainline and pipeline laterals. Regulations require a manual of written procedures for operations, maintenance, and emergencies that addresses the following topics:

- Training and qualifications of unsupervised employees and contractor personnel to operate and maintain the pipeline system would be in accordance with all applicable regulations and guidance. Operating procedures would address routine and emergency tasks.[6]
- Periodic in-house training classes would be required for operation and maintenance personnel to maintain qualifications, refresh their understanding of abnormal operating conditions, and review safety, maintenance, operations, and emergency procedures.[12]
- Annual testing and inspection of pressure-limiting devices and emergency shutdown systems would be conducted.[7]
- Patrolling pipeline routes would be conducted at specified time intervals in accordance with the applicable regulations and guidance.[13]
- Measures to ensure that corrosion would be controlled to prevent pipeline leakage and failure.[13]
- Measures to ensure that pipeline integrity would be managed to protect public safety and the environment.

5.6.1 Offshore Pipeline Safety Standards

Offshore pipelines must be designed, constructed, operated, and maintained in accordance with the DOT Minimum Federal Safety Standards under the PHMSA.[8] The regulations are intended to ensure adequate protection for the public and to prevent natural gas facility accidents and failures. The regulations also specify material selection and qualification; integrity management; operator qualification; and pipeline protection from internal, external, and atmospheric corrosion.[9]

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[6] 49 CFR 192, Subpart N.801-809
[7] 49 CFR 192.605
[8] 49 CFR 192 et seq.
[9] 49 CFR 192 et seq. Design -Subpart C; Construction - Subpart G; Operations - Subpart L; Maintenance - Subpart M. Materials - Subpart B; integrity Management - Subpart O; Operator Qualification - Subpart N; Corrosion Protection - Subpart I

BOEM, through delegation from the Secretary of the Interior, has authority to promulgate and enforce regulations for the promotion of safe operations, to protect the environment, and conserve natural resources of the OCS, including pipeline transportation of mineral production and the approval of rights-of-way for the construction of pipelines and associated facilities on the OCS. Proposed offshore pipelines impacting a fairway or anchorage area must be covered by a right-of-way permit obtained from BOEM.

5.6.2 Offshore Pipeline Incident Data

Table 5.6-1 provides information on offshore natural gas transmission pipeline incidents as reported by DOT PHMSA. The data presented in Table 5.6-1 are specific to offshore pipelines.

Table 5.6-1. Offshore Natural Gas Transmission Pipeline Incident Summary by Cause

Cause	2000	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Corrosion, External	1	0	0	0	1	0	0	0	0	1	2	0	2
Corrosion, Internal	7	2	8	5	11	5	4	9	2	6	14	6	11
Excavation Damage	1	1	0	1	0	0	0	0	0	0	0	1	0
Incorrect Operation	0	0	0	0	0	1	0	0	0	0	0	0	0
Construction/Material Failure	0	0	2	0	0	4	6	4	2	0	3	2	1
Damage by Natural Force	0	1	2	1	5	32	0	0	18	2	1	0	0
Damage by Outside Force	0	1	2	1	2	5	2	3	0	2	1	4	0
Other	0	0	2	0	0	1	7	4	4	2	1	0	0
Total	**9**	**5**	**16**	**8**	**19**	**47**	**19**	**20**	**26**	**13**	**22**	**13**	**14**

Source: PHMSA 2013
Note: Historic totals might change as PHMSA receives supplemental information on incidents.

It should be noted that external corrosion is generally not considered to be a problem for offshore pipelines. The sacrificial anode system has been shown to provide successful lifetime protection against external corrosion (MMS 2000b).

5.6.3 Offshore Third-Party Hazards

Damage from outside forces poses the greatest threat to pipeline safety. BOEM and PHMSA require subsea pipelines to be constructed and operated with specifications that minimize these outside forces.[10] It is unlikely that subsea pipelines would pose a significant hazard to public safety or natural gas supply reliability. The Applicant proposes no extraordinary measures beyond regular inspections and maintenance of the proposed Mainline and pipeline laterals.

Anchor hooking of a pipeline could displace the pipeline to a point where it distorts and structurally fails and could possibly puncture the pipeline, leading to a natural gas leak. The worst credible case for an offshore pipeline rupture would result in a loss of all natural gas occurring along the pipeline's length. However, any significant damage would be unlikely from this type of event because natural gas would bubble to the surface, dispersing first in the water column and then dissipating in the air. In the highly unlikely event that a ship located in the area provides an ignition source, a fire could develop. Because the methane would be unconfined, there would be no explosion. The resultant fire would be of short duration, but could present a safety risk to individuals on the third-party vessel. An anchor or net snagging the pipeline risers or delivery terminus interconnect could result in damage to the proposed Project's infrastructure or the third-party vessel. The Safety Zone, NAAs, ATBA, and Deepwater Port Operations Manual vessel traffic monitoring and warning procedures would minimize the risk of such incidents.

[10] 49 CFR 192.317